ABSTRACT
Marathons have gained increasing popularity in recent years for both athletic competitors and those with fitness goals. Major marathon events attract at least 20,000 race participants and even more spectators making it a formidable task to locate one’s friends and family. Supporters have an even more difficult time getting updates on the location of race participants since sections of the running path are closed to the public. This paper addresses the need for a location-aware device for real time communication among race participants, race volunteers and supporters in the audience during a marathon event.

Author Keywords
Marathon, social network, running, location-aware, physical activity, fitness, real time, race results.

ACM Classification Keywords
H5.2. [Information Interfaces and presentation (e.g., HCI)]: User Interfaces – Evaluation/methodology.

INTRODUCTION
Marathon running is an exciting sport designed to test endurance. This popular pastime attracts large crowds both for its fitness appeal, adrenaline rush and tremendous sense of accomplishment. With race participant numbers starting at least 20,000 and spectators numbering at least 50,000, finding friends and family becomes a daunting challenge. In addition, competitive runners are unaware of race statistics, times and place while running a race. This paper will address opportunities to enhance communication among these parties.

Walkers and spectators typically carry mobile phones however runners do not. Even with mobile phones, other factors work against communication. Loud music at the starting line, crowds talking and the dark early morning hours drown the cell phone’s visible cues and ringtones during an incoming call. Spectators immediately lose contact with race participants at the starting line. Even race participants eventually separate during a marathon. This paper addresses the need for real time communication for runners, audience members and race volunteers during a marathon race.

RACE SCENARIO
You’re immersed in a crowd of 20,000 people all hyped and ready to run just as you are. Just 30 more minutes before you set on your journey of 26.2 miles. The starting line is beginning to get filled, better secure your spot in front if you want to make a head start. Timing chip’s on securely fastened on shoe laces. The crowd gets denser around you; it’s 5am and dark. You prepare to stretch your muscles. Meanwhile the emcee tries to condense time by playing music videos on the large TV screen. Runners are interviewed and given air time. It’s crowded, loud and chilly and you’re invisible. No friends in sight whom you’re supposed to meet. No cell phone. Your supporters lost in a sea of endless moving heads. Time passes by but not quickly enough. The atmosphere is packed with adrenaline; runners are omnipresent around you, the countdown in on!

THE SPORT
“The marathon is a charismatic event. It has everything. It has drama. It has competition. It has camaraderie. It has heroism. Every jogger can’t dream of being an Olympic champion, but he can dream of finishing a marathon.” – Fred Lebow, road-racing pioneer and founder of the New York City Marathon [9].

A marathon’s distance is 26.2 miles and finish time ranges between 2-7 hrs. With runner participation exceeding 20,000 participants in large races not including spectators (supporters and public at large), keeping in touch becomes a challenge. Starting lines are crowded and loud. Cell phones are the only means to communicate provided the desired party has a loud ringtone or a vibrate mode setting. In addition, race participants may choose not to carry cell phones with them.

REQUIREMENTS GATHERING
In interviews with 8 participants in recent Disney races, the following questions were asked:
1. How long have you been running?
2. How many miles do you train a week?
3. How do you improve your performance for every race you run?
4. What do you measure? Time? Distance? Other people in your age category?
5. How do you track your target while running?
6. What impact, if any, do other participants have on your race time?
7. Do you check scoreboards after the race? What info do you look for?
8. How do you communicate with friends and family during a race?
9. How do they find out which mile marker you are at?
10. Do you run with friends?
11. Do you run together? If not, how do you keep track/communicate with one another during and after the race? Are you aware of each other’s location? If so, how?

Results
Four categories of people were found:

1. Runners: goals are to compete and beat personal best time. Pace is in the range 5 ½ to 10 minutes per mile. They range from being fairly to very interested in the scoreboard for overall performance and age group performance. They run hands-free, carry adrenaline shots, may possess a Garmin, tend to carry no cell phones and typically do not communicate during a race. They run with friends but will part ways during the race to run at their own personal pace.

2. Walkers: primary goal is to finish the race. They may or may not care about tracking personal best time and can be motivated by a finisher’s medal. They are usually not interested in the race scoreboard. Pace is typically between 10 to 15 minutes per mile. They tend to carry a pouch containing car keys, cell phone and adrenaline shots. This group communicates with friends and typically stays with friends to the finish line.

3. Spectators: most are supporters cheering race participants who are family, friends or roommates, others are volunteers and the public at large. Their last contact with participants is at the starting line. They usually cannot view the event for the entire course since viewing areas are limited to specific mile markers. Most wait at the finish line. Unless the race participant carries a cell phone, there is no way to communicate. Furthermore, spectators have no real time information to find the mile marker for the interested race participant.

4. Race organizers and volunteers: this group ensures that the race begins on time, directs runners towards the right direction while on the running course, provides water and other refreshments, notifies gun time at each mile marker and serves snacks at the finish line. They are also responsible for the baggage claim area and keeping runners moving past the finish line to the spectators’ area.

RACE LOGISTICS
In popular races such as the competitive Boston marathon; Miami, NY and Disney marathons, every race participant is given a timing chip. Several base stations are set up along the race course, typically 3 to 6 in marathons, one located at the starting line to start the timer and one located at the finish line to end the timer. When a runner crosses the base station, the current time is recorded along with the unique identification number for that timing chip. Based on this unique identifier, runner’s information such as race number, name, age and sex can be found.

This information today is used only for tracking official time and is available to runners and spectators as early as within a couple of hours or it may be the next day before results are posted. These results are usually located on the race website. On the other hand, gun time is available immediately after the runner completes the race. Gun time begins when the gun declares race start until the runner finishes the race. This gun start time is the same for every race participant. However, with as many as 20,000 participants in a race, it takes at least 30-45 minutes for everyone to clear the start line. Gun time does not factor this delay and ironically, gun time is used to distribute race prizes at the conclusion of the race. Prizes in marathons are given to top 3 overall male/female (M/F) winners, top 3 in fifteen standard age group categories and M/F in masters (age 40+), wheelchair and military. They include trophies, plaques and sometimes cash incentives. To provide feedback to runners, race organizers provide mile markers along the race course. Each mile marker is a road sign showing the mile number. Race volunteers are placed at various mile markers to call out gun time. Marathons are also not postponed due to inclement weather except in the event of lightning within 6 miles from the event area.

Challenges
Several communication problems exist in marathons:

1. Race participants are unable to find their friends at the starting line and finish line. A designated area is usually agreed upon by friends but may not always work. In addition, friends planning to meet at the finish line are unable to wait at the finish line crossing area. Race participants are ushered along the finish path to the spectator’s viewing area. The finish path consists of volunteers who retrieve the timing chip, distribute finisher medals, supply finishers with energy drinks and snacks and ends with a professional photographer. Once a race participant has completed all these stops, there is no returning to the finish path – it is one way. Thus race participants have to locate one another in the large spectator area. They select a designated spot to meet or look out for...
one another near the finish line. For night races, they may decide not to split up at all. One interviewee noted that on one occasion, all participants were required to wear the race T-shirt provided by race organizers and due to rainy weather, she was unable to locate her sister near the finish line since everyone looked exactly the same and she could not see clearly when looking at participants crossing the finish line.

2. Race participants get limited real time information about their times, pace, current mile marker and information about other participants in the course such as current rankings. In some cases, mile markers may not be placed at every mile and secondly, runners may miss seeing a mile marker at 5 am in the dark.

3. Race participants are unable to communicate with spectators unless they carry a cell phone. From my interviews, runners tend not to carry cell phones but walkers do.

**Solutions**

Location-aware devices bridge this communication gap in three main ways:

1. Provides location information to all parties i.e. runners, walkers and spectators.

2. Provides a race participant’s location along the race course to aid the 3 groups of people listed above.

3. Provides current mile marker position

In particular, the benefits to each group are listed below:

1. Runners: competitive runners can track their personal time, where they are along the race course in relation to other runners - their overall rank, category (male or female) rank and age group rank. This allows runners who are competing for prizes to adjust their pace accordingly in order to win a prize.

2. Walkers: for keeping in touch with supporters and tracking personal time and getting real time updates on miles completed.

3. Spectators: for finding out where interested race participants are along the race course and expected time to completion.

Since most runners do not carry cell phones with them during the race, building software on a cell phone is not an option. Avid runners however do carry a GPS device such as a Garmin to track their times, distance and pace. Therefore a design solution would be a device similar to a wrist watch that would give runners rank information on a very lightweight device. Walkers and spectators are much more likely to take their cell phones with them and hence communication can be facilitated by using GPS already built into cell phones. In addition, since some major races do set up large screen displays, for instance Disney’s Tower of Terror 13K. This display can be used to show general information about the distribution of race participants along the entire race course. Large screen displays however are not very common in races.

Based on the requirements gathered from interviews, the most prominent problem faced by everyone is the inability to locate one another in a huge crowd. This problem occurs for both runners and walkers. Race participants also rarely stay with their buddies during the entire race since this impedes them from beating their personal best time. Eventually a separation occurs hence the need for a location-aware device to easily locate one another. In addition, race participants are inherently separated from their supporters at the starting line. Based on these observations, walkers and spectators tend to carry cell phones with them and are more likely to interact during the race. Runners tend to be very focused on their pace and will not engage in any communication with supporters.

**PROTOTYPE**

This prototype will focus on getting real time information during the race. In particular, spectators are most interested in finding a race participant’s status during the race. Competitive runners trying to beat personal times and win prizes will be interested in their current pace as well as their current rank. Since mobile phones will be common among walkers and spectators, a mobile phone can be used for location awareness information and also for interacting with spectators. Runners, on the other hand, will more likely wear a wrist-watch device that has built-in GPS for tracking their times and other statistics. Runners focus on running and maintaining a steady pace hence the information provided to runners will have to be in the periphery of their attention. Interacting with spectators or family members in the audience is highly unlikely. The following information can be offered on the prototype device (either a mobile phone or a device similar to a wrist-watch):

1. Subscription to find status on a particular race participant’s location. Given a race number, the device will track where the runner is located (e.g. current mile marker) based on information gathered from the timing chip when the runner crosses a base station. The more base stations placed along a race course, the more frequent and accurate the updates. In addition, based on pace estimates, the device can predict where the runner is likely to be located along the race course. The location can then be corrected once the runner crosses another base station. This helps spectators plan better for their arrival at the finish line instead of waiting impatiently and looking at each runner cross the finish line.

2. Personal tracking statistics such as gun time, chip time, pace and miles run along the race course.

3. Ranking statistics based on runner’s goal e.g. if the runner is interested in placing top 3 based on an age category, then the runner will be interested in the gun time, pace and current mile position of others in that age category.
category. Additionally, the device can calculate what the current runner’s pace should be if top 3 status is to be achieved.

4. An audible sound played to let runners know their current pace and time when each mile marker is crossed. These updates can be configured based on the runner’s preferences. In addition, runners can also pre-set other audible notifications such as when their pace drops or they are no longer in the top 3 rankings.

Other suggestions described below will not be included in this prototype:

1. Create a social network for runners. As described in [6], runners have a hard time finding training partners. With roughly 20,000 participants in a race event, participants can choose to subscribe to a service that helps them find other runners from their area with the same running pace.

2. Runners can find other runners to run with during the race provided they have the same running pace. They can thus keep each other in pace and motivate each other as they approach the final difficult miles of the race.

3. Race organizers and volunteers can also provide real time notifications about the race course such as water puddles ahead, road track turning into dirt and gravel path, race track about to narrow significantly, U-turn ahead, about to approach a water/Gatorade stop where water is on the left but Gatorade is on the right, etc. Race participants can optionally choose to receive these notifications.

4. Walkers ahead in the race course can provide tips to other race participants behind them. Such information would include encouragement notes, tips about dirt paths and what to expect, the next Porta-Potty stop, steep incline up ahead, etc.

5. Gun time (instead of chip time) is used today to award prizes since competing athletes would have a difficult time knowing whether the runner next to them had for instance a fifteen second advantage due to a later start. However chip time is really the true measure of how long it takes a runner to complete the race and should be used in marathons for tracking performance. By calculating race participant’s actual time vs. distance run and displaying this information in real time to runners, competing athletes can be better aware if they are ahead in the race without relying on the runner next to them. In addition, race organizers will no longer need to rely on gun time which is an inaccurate measure of time especially considering that only about 100 out of 20,000 athletes can be at the starting line and have chip time equal to gun time.

EVALUATION CRITERIA
For this device, an evaluation is only possible in the field using ethnography. A preliminary pilot study can be done however to determine whether the real time information provided is pertinent and sufficient for tracking race statistics. The target user population will ideally be competitive runners for tracking and race statistics. Walkers and family supporters can also be interviewed to determine whether the location information is adequate.

Running clubs in the Tampa Bay area frequently have weekly meets where runners train with one another. First, an interview can be done to evaluate the interface to determine whether the information provided is useful. Secondly, a trial test can be performed during one of these weekly runs to test the product while running. Due to time constraints however, only interviews to evaluate the interface will be done. Additionally, the prototype will not be developed on a mobile phone. As clearly illustrated by talking to runners, they do not carry cell phones with them while in a race. The device will have to be a lightweight wrist-watch device similar to a Garmin with built-in GPS capabilities. For this prototype, a Java application will be developed to represent the interface with the limited screen estate of a wrist watch. Questions that will be asked include:

1. What are your goals during a race?
2. Does this device provide sufficient real time information to help you achieve your goals?
3. What real time information is missing that you need to see?
4. What do you like about this device?
5. What do you dislike about this device i.e. the look and feel, interface, information layout, statistics provided?
6. Will you use this device in a competitive race? Why or why not?

Walkers and supporters will be more interested in locating race participants:

1. How often do you need updates about whereabouts of the race participant?
2. Does this device provide sufficient tracking information?
3. If so, how did the device help you?
4. What information would you have liked to see that was missing?

PRIOR WORK
This section includes work done both in the commercial and research area for runners. The first three products: Garmin Forerunner 305, BiM Active and Nike + iPod are available on the market today and are used primarily during training runs. The remaining applications are from the research arena and vary from having a remote running partner to tracking custom statistics during a marathon.

Garmin Forerunner 305
The Garmin Forerunner [4] is one of the most popular trainers used today and is equipped with GPS to track distance, pace, heart rate and time. The device is similar to...
a wrist watch which is hands-free and convenient for runners (see Figure 1). A virtual partner is also featured for competitive training for helping runners meet their training goals. In addition, running courses are saved so that a runner can race against a previous course to match or exceed prior pace. Even though the Garmin has GPS, its capabilities are standalone and meant for individual training. This device was not meant for real time information from marathons.

![Garmin Forerunner 305 display](image1)

**Figure 1: Garmin Forerunner 305 display**

**BIM Active**

Bones in Motion (BiM) Active [1] is a location-aware fitness tracking application that runs on a mobile phone. BiM monitors workout activity by tracking speed, distance, pace, calories burned, running route and elevation changes (see Figure 2). It also has an odometer, weather and location information and runners can choose to have an audio tone played for any mile interval such as every ¼ mile, 1 mile, etc. The runner selects the OK button for BiM Active to start recording and tracking statistics. Once the runner’s workout is done, this data can be uploaded to the runner’s personal BiM online account to analyze personal training history.

BiM Active is inconsistent when run on different carrier’s mobile phones. Depending on the phone and the wireless carrier, some runners may not be able to accurately record their mileage and listen to music at the same time. Similarly with taking photos or receiving text messages while the application is running. These interruptions can result in incorrect tracking statistics since the application is either temporarily stopped or moved into the background to be suspended. Runners also have to reselect BiM Active from the Java menu on their phone to bring the application back to the front from suspended mode. This limitation requires too much attention from a runner to reinstate the application. BiM Active also does not work with Bluetooth GPS devices. Runners can take their mobile phones with them by either strapping the phone to an arm band or holding the phone in their hands. Similar to the Garmin Forerunner, BiM Active is meant for individual training and does not get real time information from other runners during marathons.

![BiM Active](image2)

**Figure 2: BiM Active**

**Nike + iPod**

Nike and Apple [5] partnered to create a sports kit to help train runners while still enjoying the benefits of their iPod Nano. The Nike+ shoe contains a built-in pocket under the insole to hold the iPod sensor. This sensor uses an accelerometer to track the runner’s activity and wirelessly transmits the data to the receiver on the iPod Nano. The receiver must be plugged into the dock connector of the iPod during the workout. The iPod Nano plays music for the runner and also provides voice feedback regarding the training workout. Voice feedback also congratulates the runner once the personal best time is exceeded. The interface consists of a large red counter that displays the time, distance, pace or calories burned (see Figure 3). In addition, the iPod stores up to 1,000 workouts.

![Nike + iPod interface](image3)

**Figure 3: Nike + iPod interface**

**Jogging the Distance**

O’Brien et al [6] developed a mobile phone application for joggers who prefer to jog with friends in a non-competitive manner. These joggers enjoy companionship and talk to their running partners for fun, motivation, encouragement and socializing and are hence referred to as social joggers. Since social joggers have a difficult time finding a running partner with the same pace, duration and location, Jogging the Distance uses audio to connect remote jogging partners and even joggers running at the different pace in the same location.

A mobile phone is attached to a headset so that both joggers can communicate to each other. The audio in the headset is spatially adjusted so that the jogger hears audio coming from the front, back or behind depending on the relative position of the remote jogger. Since 18 of their 32 interviewees (who were personal contacts or from local running clubs) preferred jogging with someone else, this application specifically supports this group of social
joggers. Ironically, each of the participants owned a mobile phone but none used it while jogging. Their study revealed positive results for the social joggers who relied on support and encouragement from each other. Improvements suggested were for the application to communicate partner’s condition such as pace, to communicate partner is approaching incline, to support silence during mobile phone conversation and to allow for asynchronous jogging start times. Jogging the Distance is used only for those joggers who run with others in a non-competitive environment. This paper focuses on those runners who run in competitive races and also includes runners who do not socialize while running.

**Actively Mobile**

Bove [2] designed a prototype for an ideal running device that would contain a phone, speedometer, pedometer, music player, heart rate monitor, location tracking and chronometer (tracks runs and compares with previous workouts). In her interviews, almost all the users take their phones everywhere they go except when they exercise. They found that the phone was too bulky, difficult to carry, cumbersome and did not fit into their workout very well. In addition, an incoming call distracts a runner’s concentration and interrupts the runner. Her prototype was an all inclusive device that would be lightweight, use audio commands to control and have buttons aligned with the natural position of fingers holding this device. The services that this device would offer include:

1. **Buddy runs** – two runners in different locations can connect during a run.
2. **Goal setting/motivational prompts** – runner sets pace goals and gets automatic encouragement.
3. **Locate partner** – finds running partner who arrives late to an organized meeting point.
4. **Pace setting** – one runner sets the pace for the other.
5. **Route finder** – for finding a narrated tour along new course.
6. **Route tracking** – first runner sets the route so second runner can “follow the tracks” of the first runner.
7. **Sharing audio tracks** – two runners listening to the same music.
8. **Smart playlists** – tracks played based on heart rate, pace or mood.

Bove’s thesis focused on the ideal device an athlete would need during training and does not focus on competitive races.

**MarathonNet**

MarathonNet was designed by Pfisterer et al [8] to monitor runners using wireless sensor networks. Runners wear a wrist watch device called Pheidippides which records runner ID, heart rate, timestamp and location information which is transmitted to a base station using a wireless connection and eventually to a centralized database. This paper focused on the number and placement of these base stations needed to support a wireless multihop connection among the devices and between the base station and the central server. The data collected can be used to help runners document their performance, optimize their training sessions and compare their performance with their training partners. Friends of athletes can track their location using the Internet and a text message can be sent to friends as a runner approaches the finish line. Organizers can use the heart rate data to determine if medical attention is needed by the runner. Timestamps provided by the base station can determine if a runner is cheating by leaving the race course or taking short cuts.

Data plotted for 500 marathon runners showed that runners follow a Gaussian distribution since a small number of race participants are much faster or much slower than the remaining participants. Since the distribution curve is heavy-tailed at the lower end, the connectivity to the base stations was only at 80% success rate (with 8 base stations and communication range between base station and central server at 200m). Thus a single base station was not able to drain the data described above from 500 Pheidippedes devices.

While MarathonNet has applications for real time communication during a race, the data collected informs family and friends using one-way communication (text message) and does not include any real time interaction among walkers and the audience. Additionally, their paper focused mainly on gathering the data from custom base stations and also collecting additional data such as heart rate. This paper will use the existing infrastructure currently being used in marathons to track only runner ID and timestamp that currently works commercially today [3]. This data will feed into an interactive application to facilitate communication among race participants and spectators in real time.

**MPTrain**

MPTrain [7] is a mobile phone system that monitors a runner’s heart rate and speed in order to tailor music delivered to the runner. The music is selected with different beats, volume and tempo to encourage the runner to speed up, slow down or keep at current pace based on the runner’s exercise goals. MpTrain has wireless physiological sensors that feed data back to the mobile phone using a Bluetooth transmitter. MPTrain does not take any action however until 10 seconds before the completion of a song so there is a time lag for correlating pace with music tempo. In addition, MPTrain is a system for helping runners train more effectively based on their end goals and does not provide any interaction among runners during a competitive race.
ARCHITECTURE
Every runner wears a timing chip so that race organizers can track “net” time or “chip” time. The chip has a unique identification number for every runner and an energizing coil. Moreover no batteries are inside the chip. Several mats are placed along the race course that activate the chip in a magnetic field, producing an electric current that powers the chip to send its own identification number to a receiving controller box. This process completes within 60 milliseconds [3]. The controller box stores the chip’s ID along with the current timestamp and the data is passed to race scoring software (computer station in Figure 4). This scoring software tabulates the data by finding the corresponding runner’s information such as race number, age, city and links the timestamp results. Hence overall results, age-group results and web posting results are easily generated opening the possibilities for real-time updates (see Figure 4).

Figure 4: Architecture diagram for real time marathon results
Each application device subscribes to race statistics such as top 3 times, runner’s chip time, gun time, pace or overall best time. Once the data is transferred from the computer station to a server, timestamp and the current runner’s bib number will be transmitted on the application device. Only timestamps though of other runners will be displayed (to protect other runners’ privacy). The data will be used to display real time results that the runner has subscribed to.

PROTOTYPE INTERFACE
The proposed interface will be designed to fit a wrist watch display since runners are likely to wear these devices during a race. This poses a major constraint however since screen estate will be limited to just 3 inches x 3 inches. A Garmin Forerunner 305 today has dimensions 4 inches x 4 inches x 4 inches. The runner’s gun time, chip time, pace and race course position will be shown. In addition, the following real time services can be subscribed to: top 3 overall times, top 3 women or men, top 3 in age category.

The runner will enter information such as bib number and age into the device before race start time and select the services to subscribe to. For marathon races the entire race course will not be shown on the display due to limited screen estate. Therefore, depending on the services that the runner subscribes to, for instance, top 3 by age category, then only the fraction of the race course showing the positions of those top 3 runners can be shown. Approaching water stops are valuable information for runners and this will also be displayed on the race course. In addition, pace times for the top 3 runners determine what speed (miles per minute) the runner should target to be in the top 3 rankings.

Runners may also enable audible feedback where they will be notified in the background of several milestones during the race. These notifications can include time for each mile marker, approaching water stops, current pace and pace of next ranked athlete.

Figure 5: Prototype drawing of interface for real time results
The interface above (Figure 5) shows race course information, water stops, mile markers and also the top 3 runners by age category and their pace. The green dot represents the current runner’s pace. Gun time and chip time are displayed on the lower right corner.

PROTOTYPE IMPLEMENTATION
Figure 6: Java Prototype Implementation

PROTOTYPE EVALUATION STUDY
Five runners from the Tampa Bay Runners Club were interviewed after a weekly run. One runner (referred henceforth as Runner #1) is in the age range [30-39], one (Runner #2) in [40-49] and the third runner (Runner #3) is in the [50-59] age group and the remaining two runners (Runners #4 and #5) are in the age range [20-29]. All runners competed in several races across the state including marathons and have pace ranges between 8:00 and 6:00 minutes/mile.

An informal open interview was conducted to determine if the interface designed above would meet their needs while running a marathon or a smaller race. Runners were asked about their goals during a race, whether the device provided ample real time statistics, their likes and dislikes about the interface and what could be done to improve the display. Finally runners were asked if they would use this device in their next competitive race.

Three of the runners had goals to be top ranked in some category, either by age range or being in the top percentile of finishers. The remaining two runners were more interested in personal best time and pace.

EVALUATION
Overall, runners had positive responses for receiving real time marathon statistics and 3 of 5 runners asked if there were plans to market this device! 4 runners said they would definitely use this device during their next marathon. The following sections are divided based on the features of the interface.

Race Statistics
All runners agreed that the minimum information they would require are gun and chip times, miles run and pace. They also commented that seeing the pace of the other athletes would be the most valuable information about their competitors. Runner #1 suggested that he would need a heart rate monitor as well since heart rate varies depending on weather conditions such as humidity, temperature and heat index. Heart rate was an important measure for him to track his performance during a race and to alert him how to pace his run.

Device Characteristics
All runners also agreed that if this application was provided on a mobile phone, they would not carry this device during a race and would not use this application. A wrist watch device was the only viable option they would agree to. However for this prototype, all runners thought that the screen size was too large for a wrist watch device and would add to its bulk making it cumbersome to run with. Runner #2 commented that he has problems figuring out where to put his car keys when he runs and would not run with any device whose size was larger than the Garmin Forerunner 305.

Screen Display
All runners were concerned about the font size of the gun and chip times displayed. They noted that the font was too small and they would like the ability to view at a glance their running statistics and did not have the time to figure out their times or miles run. All 5 runners did not want to interact with the device for very long since viewing/interacting with the device takes away their running concentration and slows down their pace. Runner #2 required one easily accessible “Update” button which he could use while running to get the valuable statistics: pace, miles completed, gun and chip times. He also added that the mile markers on the map were too small. Furthermore, runners noted that they did not want too much information displayed because this would confuse them while running and looking at the device to get quick real time updates.

Audible Feedback
4 of 5 runners liked the voice feature which they could configure to have auto-updates during splits. Splits are segments of the marathon chosen by the runner to track pace and determine performance, for instance, getting pace and time updates for every mile marker. With the voice feature, they spend less time looking at the device and focus instead on their running pace. Runner #3 though, in the age range [50-59] suggested he would need the device to have a Bluetooth headset so that he could clearly hear the audible updates. Runners #4 and #5 requested the voice to be female and they wanted to choose encouraging remarks based on their pace such as “You can do it!” Runner #2 suggested that the voice should say, “Speed up old man!” whenever the device detected a slowdown in pace.

Course Map and Competitor Rankings
4 of 5 runners liked the map interface and especially the location of other competitors. Runners #1, #4 and #5 added that they were indeed interested in placing top in their age groups. Runner #4 recalled placing 4th in a recent race and wished he had this knowledge before the conclusion of the race so that he could compete for top 3 in his age group. He was recovering from an injury and reduced his pace but would have definitely aimed for top 3 if he was given a real
time rank notification. Runner #2 said he was not interested in any top 3 rankings but would rather have real time statistics to find out if he placed in the top 30th or 50th percentile. However, runner #3 was interested only in tracking his pace, chip time, gun time and miles run and did not see a need to view other athletes’ location or pace. He only wanted to see his own running statistics.

Lastly, runners #4 and #5 had concerns about the map interface. Runner #5 was unsure what would be displayed on the map for a full marathon and did not believe that the entire race course could be shown. In fact, for a full marathon (26.2 miles), only a portion of the race course will be displayed depending on the runner’s location. Runner #5 agreed this would not be a problem to see only part of the race course at a time. Furthermore, runner #4 was concerned that the current prototype to have a long battery lifetime as well, lasting at least the duration of a full marathon (which is usually allotted 7 hours by race officials). 2 of 5 runners liked the water stop visual indicators on the map while the remaining 3 did not care for this information. However, showing water stops can be a configurable option on the device where runners can choose whether they want this information displayed on the course map.

Overall Impressions
4 of 5 runners said they would use this device for marathon races. Runner #3 said he would not purchase this device if offered on the market. Pace, chip time and miles run was sufficient information and he did not want to learn how to operate this new device. In addition, he was not interested in other athlete’s race statistics. The other runners thought that the idea was promising and had marketable value. They were interested in real time personal statistics such as gun and chip times, pace and mile information and as competitors, also wanted to know the pace of other athletes as well as their distance covered. Overall, a positive and encouraging response was received regarding the useful application of this device during a marathon race. Suggestions were to make the device a smaller size where the display is no more than 1.5” x 1.5”, the fonts should be large to read at a glance and should provide a quick way to gain race statistics with minimal interaction while running.

CONCLUSION

FUTURE WORK

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REFERENCES